HPS™ Products

HPS™ Series 937A Controller

RS-232 / RS-485

OPERATION AND MAINTENANCE MANUAL

MKS INSTRUMENTS

HPS™ Products

HPS™ Series 937A Controller

RS-232 / RS-485

November 1999
PART #100009182 REV. A1

Serial # _ _ _ _ _ _

Please fill in these numbers and have them readily available when calling for service or additional information.
(The part number can be found on your packing slip, and both the part number and serial number are located on the bottom side of the housing.)

For more information or literature, contact:

MKS Instruments, Inc., HPS™ Products, Inc.
5330 Sterling Drive
Boulder, CO 80301 USA

Phone: 303-449-9861
800-345-1967

Fax 303-442-6880

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Package Contents

Before unpacking your RS-232/RS-485 Communications Module for the Series 929A or 937A System, check all surfaces of the packing material for shipping damage.

Please be sure that your RS-232/RS-485 Optional Communications Module package contains these items:

- 1 RS-232/RS-485 Communications Module
- 1 ***RS-232/RS-485 Communications Module Userís Manual***.

 If any item is missing from the package, call HPS™ Products Customer Service Department at 1-303-449-9861 or 1-800-345-1967.

Inspect the RS-232/RS-485 Communications Module for visible evidence of damage. If it has been damaged in shipping, notify the carrier immediately. Keep all shipping materials and packaging for claim verification. Do **not** return the product to HPS™ Products.

Symbols Used in this Manual

The first two symbols below, that may be located on your RS-232/RS-485 Communications module, Identify critical safety concerns. They are used throughout this manual to further define the safety concerns associated with the product.

The last two symbols identify other information in this manual that is essential or useful in achieving optimal performance from the Rs-232/Rs-485 Communications Module.

CAUTION: Risk of electrical shock.

CAUTION: Refer to manual. Failure to read message could result in personal injury or serious damage to the equipment or both.

Failure to read message could result in damage to the equipment.

Calls attention to important procedures, practices, or conditions.

Safety Information

Symbols Used in this Manual (English)

Definitions of CAUTION and NOTE messages used throughout the manual.

CAUTION: Risk of electrical shock. ISO 3864, No. B.3.6

CAUTION: Refer to accompanying documents. ISO 3864, No. B.3.1 This sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

This sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

This sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symboles utilisÈs dans ce manuel (FranÁais)

DÈfinition des indications ATTENTION et REMARQUE utilisÈes dans ce manuel.

Risque de secousse Èlectrique. ISO 3864, No. B.3.6

Se reporter ‡ la documentation. ISO 3864, No. B.3.1 Líindication signale un danger potentiel. Elle est destinÈe ‡ attirer líattention sur une procÈdure, une utilisation, une situation ou toute autre chose prÈsentant un risque de blessure en cas díexÈcution incorrecte ou de non-respect des consignes.

Líindication signale un danger potentiel. Elle est destinÈe ‡ attirer líattention sur une procÈdure, une utilisation, une situation ou toute autre chose prÈsentant un risque díendommagement ou de dÈg,t díune partie ou de la totalitÈ de líappareil en cas díexÈcution incorrecte ou de non-respect des consignes.

Líindication REMARQUE signale des informations importantes. Elle est destinÈe ‡ attirer líattention sur une procÈdure, une utilisation, une situation ou toute autre chose prÈsentant un intÈrÍt particulier.

In dieser Betriebsanleitung vorkommende Symbole (Deutsch)

Definition der mit VORSICHT! und HINWEIS ¸berschriebenen Abschnitte in dieser Betriebsanleitung

VORSICHT! Stromschlaggefahr! ISO 3864, Nr. B.3.6

VORSICHT! Bitte Begleitdokumente lesen! ISO 3864, Nr. B.3.1 Das Symbol VORSICHT! weist auf eine Gefahrenquelle hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgem‰ e Ausf¸hrung bzw. Ungen¸gende Ber¸cksichtigung zu KˆrperverletzungfÌhren kann.

Das Symbol VORSICHT! weist auf eine Gefahrenquelle hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgem‰ e Ausf¸hrung bzw. Ungen¸gende Ber¸cksichtigung zu einer Besch‰digung oder Zerstˆrung des Produkts oder von Teilen des Produkts fÌhren kann.

Das Symbol HINWEIS weist auf eine wichtige Mitteilung hin, die auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit von besonderer Wichtigkeit aufmerksam macht.

SÌmbolos Usados en el Manual (EspaÒol)

Definiciones de los mensajes de PRECAUCI”N y OBSERVACI”N usados en el manual.

PRECAUCI”N: Riesgo de descarga elÈctrica. ISO 3864, N. B.3.6

PRECAUCI”N: Consultar los documentos adjuntos. ISO 3864, N. B.3.1 Esto sÌmbolo indica un riesgo. Pone de relieve un procedimiento, prctica, condiciÛn, etc., que, de no realizarse u observarse correctamente, podrÌa causar lesiones a los empleados.

Esto sÌmbolo indica un riesgo. Pone de relieve un procedimiento, prctica, etc., de tipo operativo que, de no realizarse u observarse correctamente, podrÌa causar desperfectos al instrumento, o llegar incluso a causar su destrucciÛn total o parcial.

Esto sÌmbolo indica informaciÛn de importancia. Pone de relieve un procedimiento, prctica, condiciÛn, etc., cuyo conocimiento resulta esencial.

Specifications

Communication Protocols

Cable length with RS-232 signals	50 ft (15 m)
Cable length with RS-485 signals	4000 ft (1200 m) May use multidrop (bussed) wiring with built-in pass-through connector
Serial Bit Rate	2400 to 19200 bps
Character Set	Standard ASCII, 0-127
Character Format	8 data bits (MSB=0) 1 stop bit Even parity or no parity

Command Set

Approximately 50 commands are available

- Read pressure on any channel
- Read pressure on all channels with one command
- Read combination output pressure
- Enable or disable hot or cold cathode sensors and hot cathode sensor degas, and determine their status
- Perform and check status of user calibration
- Set, read, and disable protection, control, and relay set points and hot cathode sensitivity values
- Lock or unlock operation of the user calibration functions, all front panel functions, or control and setup commands on the communication interface.
- Change and restore certain effective DIP switch settings within the Controller. Read the present logical state (i.e. after remote changes) of most DIP switches
- Read the state of the set point relays
- Read the type of sensors installed

RS-232/RS-485 Communications Module

The RS-232/RS-485 Communications Module is an optional accessory for the HPS™ Products 937A vacuum sensor Controllers. It allows the Controller to communicate with a host computer via an RS-232 or RS-485 serial interface. This communication allows all front panel operations to be performed, pressure readings to be obtained, and some other functions to be performed remotely. Approximately 50 different commands are available.

The two-letter forms of commands used with earlier 929 and 937 Controllers are still available.

Installing and Setting Up the Communications Module

This section covers switch settings, installation, and wiring of the Communications Module. In order to install the module correctly, it is necessary to know the desired serial protocol, bit rate, and (if used) the module address for RS-485 . To determine the settings desired for these factors, see **Serial Protocols**.

The original 937 controller supports a limited command set. The 937A supports a larger command set with an enhanced Communications Module.

An old Communications Module (part number 100006040) will not function properly in a 937A. It will not recognize any of the modules in the Controller, and the Controller will ignore it, except for a setup error at power on. Press C.C. on to clear this error. Otherwise, the Controller will function normally. These modules cannot be upgraded.

The intermediate version of the Communications Module (part number 100007746) is able to support the extended command set if upgraded with new module software. These modules function either as old or new modules, depending on the software installed in the module. The new software is contained in an EPROM (part number 100009204). Contact MKS Instruments Vacuum Products Group for upgrade information.

The new Communications Modules (part number 100009506) are identical to intermediate versions with new software. A new module in an old Controller will function the same as an old module with one exception: The new, more flexible Pn and RZ commands will also work. Refer to the Communications Module Userís Manual for more information on these commands.

EQUIPMENT USE AND MODIFICATION. The instrument must be used as specified by MKS Instruments to ensure safe operation. Use or modification of this equipment in a manner not specified by MKS Instruments may impair the protection provided by the equipment.

Removing and Installing the Module

Instrument contains lethal voltages within the enclosure. The power cord must be disconnected before any covers, modules, or cables are removed from the instrument. EVEN WITH THE POWER SWITCH OFF, DAMAGE OR INJURY MAY OCCUR.

The Controller was designed for easy access to the modules. Use a #1 Phillips screwdriver to remove the screws at the top and bottom of the module. Use a small flat-blade screwdriver to gently pry the module away from the rear frame until it slides freely. Carefully slide the module out; rapid action can cause damage to the components on the module or the internal connector. As the module is removed, place it in a static protected container.

There are two banks of DIP switches on the Communications Module. Refer to the next section to set those switches before installing the module.

It is very important to place modules in their correct slots. The Communications Module must be in the slot labeled ìCOMî. To insert the module into the Controller, insert the end with the internal connector between the card guides, so that it slides freely. Gently slide the board towards the front of the Controller. When the internal connectors meet, carefully push on the rear panel to make the connection, making sure that the screw holes fit over the threaded inserts. Replace and tighten the two screws with a #1 Phillips screwdriver.

Program Checksum Test

The program in the Communications Module performs a checksum self test. If this test finds an error, no communications functions are possible. Other Controller functions will operate normally. Contact HPS™ Products Customer Service Department to correct this problem.

If this error occurs, the RS-232 TxD output (pin 3 of the upper connector) will change state nearly every second, to allow easy detection with a voltmeter. This may cause framing errors in an RS-232 host system but will not interfere with communication between RS-485 devices.

DIP Switch Settings

Refer to **Serial Protocols** for information on choosing the proper protocol.

The selection of the desired serial protocol and bit rate is made using the DIP switch bank labeled ***SW1***. Switches 6 and 7 select either the RS-232 or the RS-485 electrical interface. Switch 5 selects the simple or multidrop logical protocol. The table **Electrical Interface and Logical Protocol** shows the allowed configurations.

If the multidrop protocol is selected, an address character must also be selected using the DIP switch bank labeled ***SW3***. The switches should be set to the binary code representing an ASCII character which will be the Controllerís address. ON represents a 0 and OFF represents a 1 bit value. Any value from 0 to 7FH except 24H (ì$î, the attention character) may be used for the address. In some systems, ASCII letters and numbers may be most convenient. ***SW3*** is ignored when the simple protocol is selected.

Switches 1-4 of ***SW1*** select the bit rate and parity. The table **Bit Rate and Parity Selection** shows the allowed combinations. Other combinations of these four switches default to 9600 bps, even parity. Use of parity is recommended where possible.

If the simple protocol is used, parity or other character errors could result in unexpected operation. This may be avoided by using the multidrop logical protocol with the RS-232 electrical interface. To do this, set Communication Module DIP switches 5 and 7 ON and 6 OFF. See Serial Protocols, Parity **for more information.**

ELECTRICAL INTERFACE AND LOGICAL PROTOCOL

TABLE 1:

CONNECTION TYPE	SW1 SETTING	
	SWITCH	POSITION
Normal RS-232		
Simple Protocol	5	Off
RS-232 Interface	6	Off
	7	On
Normal RS485		
Multidrop Protocol	5	On
RS-485 Interface	6	On
	7	Off
RS-232 Interface with	5	On
Multidrop Protocol	6	Off
	7	On

BIT RATE AND PARITY SELECTION

TABLE 2:

BIT RATE	PARITY	SW1 SETTING[1]	
		SWITCH	POSITION
2400	Even	1	On
		2,3,4	Off
	None[2]	1	Off
		2,3,4	On
4800	Even	2	On
		1,3,4	Off
	None[2]	2	Off
		1,3,4	On
9600	Even	3	On
		1,2,4	Off
	None[2]	3	Off
		1,2,4	On
19200	Even	4	On
		1,2,3	Off
	None[2]	4	Off
		1,2,3	On

1. Other combinations will default to 9600 bps, even parity.
2. Use of parity is recommended whenever possible.

PIN	DESCRIPTION
1	RS-485 DATA
2	RS-232 RECEIVED DATA
3	RS-232 TRANSMIT DATA
4,7,8	NO CONNECTION
5	SIGNAL GROUND
6	RS-232 DATA SET READY TRUE OUTPUT
9	RS-485 DATA

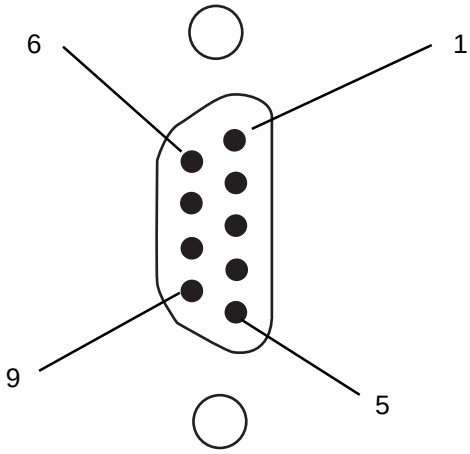


Figure 1:
RS-232 / RS-485
Rear Panel Connector (male)

RS-232 Cabling

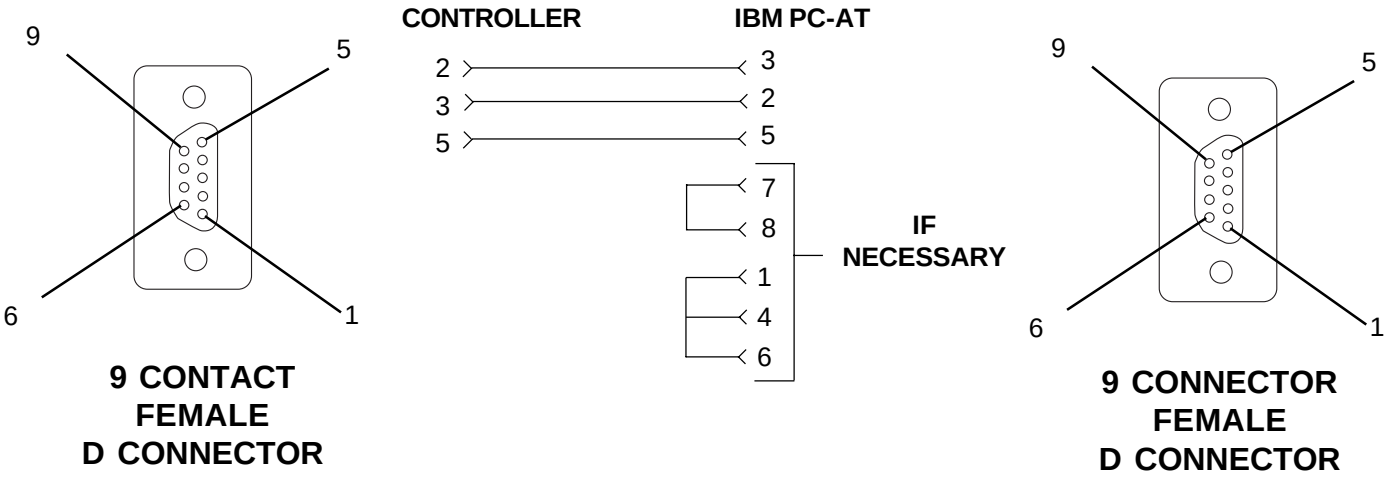
The RS-232 electrical interface is implemented using three wires, transmitted data†(TxD), received data (RxD), and signal ground (SG). RS-232 is not formally specified for distances greater than 50 feet (15 meters), although it may work. These connections on the 9-pin D connector are the same as the standard PC-AT connections for a DTE (data terminal equipment) device. These connections are given in Figure 1. Figure 2 shows a cable for connecting to other DTE devices using either the standard 25-pin D connectors or the PC-ATís 9-pin D connector.

In order to maintain compliance with the CE Declaration of Conformity of the Controller, cables with a full braided shield, properly grounded at each end, must be used. Please contact HPS™ Products Customer Service Department for more information if needed.

RS-485 Cabling

RS-485 is a differential interface, implemented with two signal wires and a ground wire. This connection allows multiple devices to communicate on the same wires. This multidrop cabling method requires a unique address for each device on the bus. Figure 1 shows the connections on the main RS-232/ RS-485 connector on the Communications Module. Figure 4 shows a cable for connecting to a host computer RS-485 port. Note that there is no standard for RS-485 connectors and the cable must be made for the specific device to be used on the other end. In order to maintain compliance with the CE Declaration of Conformity of the Controller, cables with a full braided shield, properly grounded at each end, must be used.

There is an additional RS-485 pass-through connector on the rear panel of the module, to allow the cable to continue on to other devices. Its pin connections are shown in Figure 3. Since the primary connector is male, the pass-through connector is female, and the pins used for the RS-485 signals are the same on both. This allows the Controller to be removed and bypassed by connecting the two cables together, leaving all other devices connected. The continuation cable will be similar to that shown in Figure 4 but with a male D connector (which has pin 1 on the opposite end so that it connects with pin 1 of the female connector).



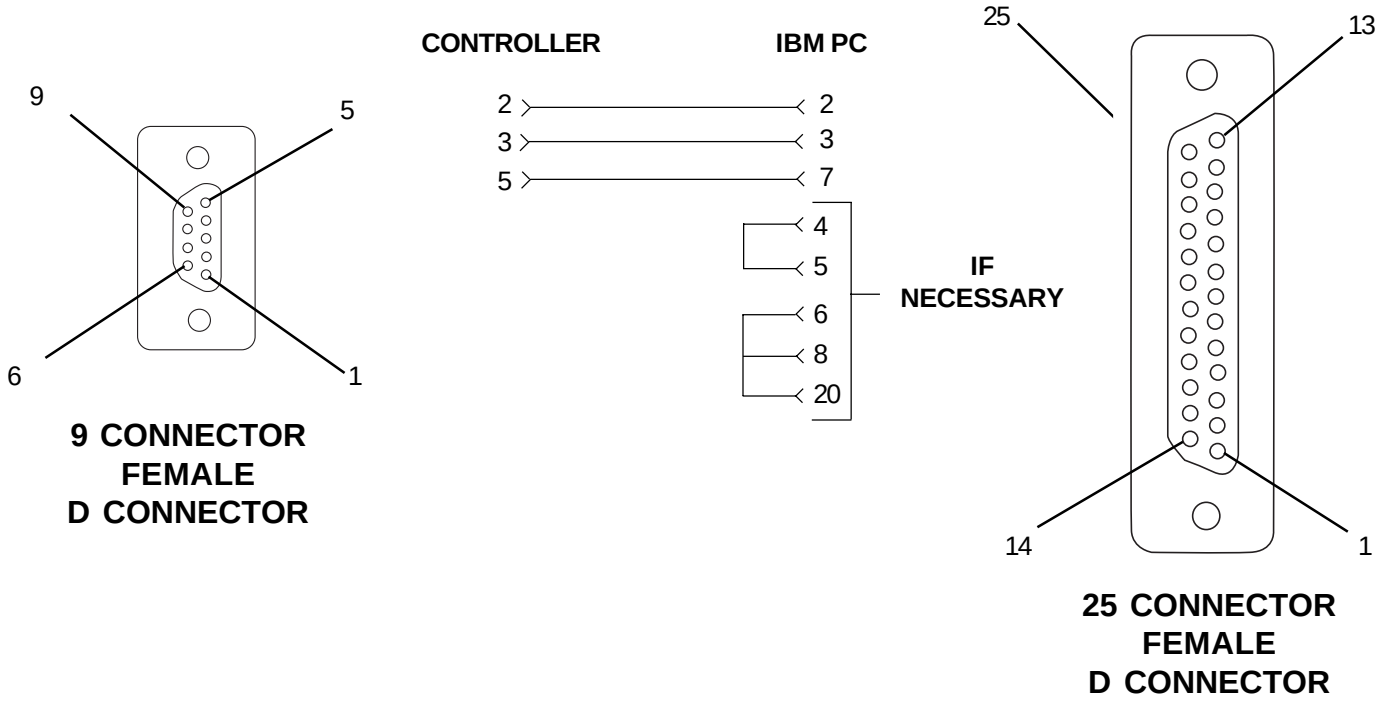


Figure 2: RS-232 Cables to IBM PCís or other DTE devices
Upper: 9 Pin PC-AT Connection
Lower: Standard 25 Pin Connection

RS-485 systems should always be connected as one long line with devices located at any point along it. There should be no branching of the line. RS-485 communications at high speed and over long lines (over about 500-1000 meters at 19,200 bps) require both ends of the transmission line to be terminated in the characteristic impedance of the cable, typically about 120 Ohms. The holes on the Communications Module marked ***R1*** are provided to allow the customer to add a termination resistor if required.

This resistor should only be used on a module if it is located at one end of the transmission line.

PIN	DESCRIPTION
1	RS-485 DATA
2,3,4	NO CONNECTION
5	SIGNAL GROUND
6,7,8	NO CONNECTION
9	RS-232 $\overline{\text{DATA}}$

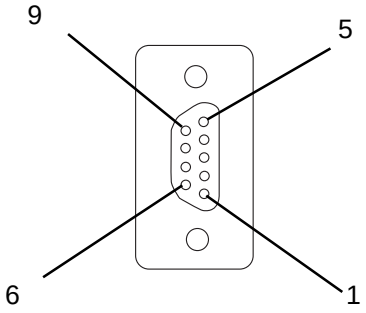
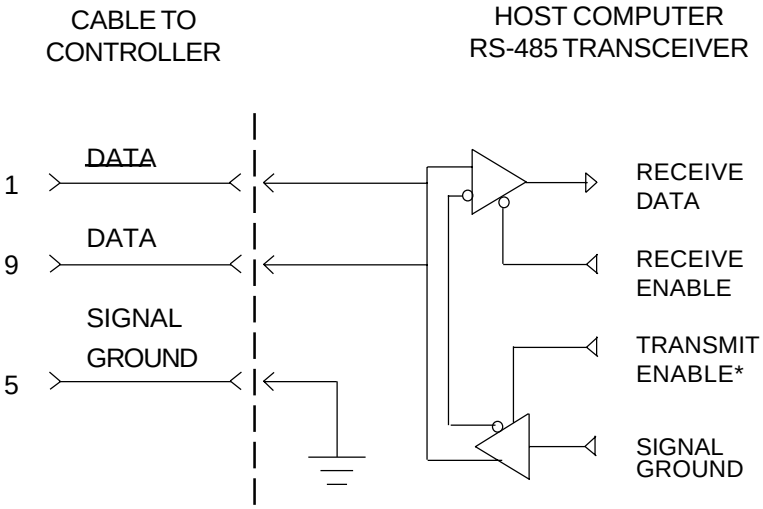
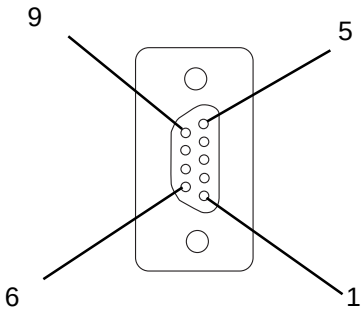


Figure 3: RS-485 pass-through rear panel connector (female)



For host connector, use connector type and pins to match host. There is no standard connection for RS-485



9 CONNECTOR FEMALE D CONNECTOR

***Host must use transmit enable to disable transmitter output when done transmitting.**

Figure 4: RS-485 cable to host computer

A Ground wire should be used with RS-485. The maximum line length of 4000 feet (1200 meters) may result in various ground problems, and may require special treatment. RS-485 receivers tolerate a ground difference plus common-mode noise of up to ±7 V.

An interface card for RS-485 may be purchased for personal computers, or an external RS-485 interface converter may be added to an existing RS-232 port. The converter must be a bidirectional, two-wire, half-duplex type. In any case, the RS-485 transmitter must be turned on before each transmission and turned off afterwards. Some converters are controlled by the portís RTS output, while others turn on automatically when data is to be sent, and turn off a period of time after it is finished. The T commands may be needed to accommodate this delay, up to 8 ms.

Please contact HPS™ Products Customer Service Department for more information if needed. Contact B&B Electronics (815-433-5100, www.bb-elec.com) for an application note on RS-485.

Serial Protocols

The serial protocols used by the Communications Module have two major components, the electrical interface and the logical protocol.

Two electrical interfaces are available, RS-232 and RS-485. These use different signal levels and cables. The RS-232 interface is a point-to-point connection, meaning that one set of wires is required between every pair of devices that must communicate. A simple protocol, without addresses, may be used in this case.

RS-485 allows multiple devices to be connected on the same wires to a host computer. This connection requires a multidrop protocol to provide a unique address for each device on the bus. To announce the arrival of the address, the attention character, ì$î (24H), must be the first character of each command sequence, and it must be followed immediately by the selected address character (0 - 7FH, except 24H). The ì$î cannot be used in any other way. The character after the address must be the first character of the command name. With the multidrop protocol, the attention and address characters must begin every command. They are not used in the responses, since all responses are assumed to go to the host.

Normally, the simple protocol is used with the RS-232 interface and the multidrop protocol is used with the RS-485 interface. However, the multidrop protocol, combined with parity, gives greater protection from character errors, and it can also be used with RS-232.

If you plan to use the simple protocol, please read the section on Parity **for more information.**

The character data format is 8 data bits, 1 stop bit, and even or no parity. Data is ASCII. The most significant data bit must always be zero (0-7FH, no extended ASCII). Rates of 2400, 4800, 9600, or 19200 bits per second may be used.

All commands and responses are terminated with a carriage return (<cr>, 0DH). Line feed characters (0AH) are ignored at all times. Neither hardware nor software handshaking is implemented. Half-duplex mode (no simultaneous transmitting and receiving) is used, and the host must receive the response from each command before sending the next command.

RS-232 is formally specified for cable lengths of 50 feet (15 m) or less. RS-485 may be used with cables up to 4000 feet (1200 m) long. Very long lines may require termination resistors at each end. See **RS-232 Cabling** or **RS-485 Cabling** for information on cabling considerations.

The remainder of this section gives more details on the serial protocols. **Installing and Setting Up the Communications Module** describes how to set up and connect the Communications Module for the specific protocol desired.

Parity

Parity provides protection against incorrectly received characters. Its use is recommended where possible. Parity may be disabled in systems that do not allow its use with 8 data bits.

Unless parity is disabled, an even parity bit is sent with each character transmitted. The parity bit is also checked for each character received. A parity error has different effects for simple and multidrop protocols.

If a parity error occurs in any byte sent to the Controller with the multidrop protocol, then the Controller will return to waiting for another command, which must start with the attention character and the correct address character. In order to avoid bus contention, no parity error message or other response is sent back to the host computer. If a parity error occurs, a host computer time-out is required to detect it by the lack of a response.

With the simple protocol, the result is similar. However, the simple protocol does not require attention and address characters. Therefore, the remaining portion of the command, terminated by a carriage return, may be misinterpreted as a different command. Therefore, if the simple protocol is used, parity errors could result in unexpected operation. This may be avoided by using the multidrop protocol, even with the RS-232 interface. To do this, set Communication Module DIP switches 5 and 7 ON and 6 OFF, and use multidrop attention and address characters with RS-232 wiring and signal levels.

Character Pacing and Time-outs

A serial character consists of a start bit, 8 data bits, a parity bit (if enabled), and a stop bit, a total of 11 bits for each character. The time required to transmit one character as a function of the bit rate is:

- 2400 bps: 4.58 ms/character
- 4800 bps: 2.29 ms/character
- 9600 bps: 1.15 ms/character
- 19200 bps: 0.57 ms/character

The Controller typically requires between 0.5 and 2 ms for processing before a response is transmitted. Thus the time between receiving the full read command and the host computer receiving the full response (up to 10 characters) should be a maximum of 50, 27, 16, and 10 ms for the respective baud rates. These time estimates include a software processing time of 4 ms. The PZ command, with its longer response, takes about 40 character times longer.

The response times listed above are for the simple protocol. When using the multidrop protocol, there may be an additional 1, 4, or 8 millisecond software delay after the end of the command, before the response starts. These delays, or no delay, may be selected using the time delay (T) commands. The default is 8 milliseconds. These delays may be required to eliminate bus contention if the host computer is slow to release the RS-485 bus after sending a command. The Controller releases the line within two bit times after the carriage return at the end of the response.

The information provided here may be used to calculate a reasonable value for a software time-out (i.e. at least 14 ms if 19200 baud and 4ms line release delay is used). This time-out is the waiting period used by the host computer to determine that the Controller has failed to respond.

The above times are for read commands only (Px, Cx, FRONT, CAL, RLYx, PROx, GAUGES, etc.). When sending a write command to the Controller (for example setting set point values or doing a sensor calibration) processing in the Controller can take up to 0.5 seconds in some cases. Therefore, a 0.5 second time-out will be required for those commands.

If the time between characters from the host computer to the Controller exceeds 50 milliseconds, then the Controller will time out and wait for a new command, just as if there had been a parity error. To avoid bus contention, the Controller will not send a response if it times out, and the host computer must time out to detect this. The same possibility for command misinterpretation exists as for parity errors, as described in **Parity**.

There is little or no delay between stop and start bits of consecutive characters sent from the Communication Module to the host computer, except for an occasional 450 microsecond delay resulting from information transfer from the Controller to the Communication Module.

Commands and Responses

The Controller never initiates communication. It only responds to commands sent to it.

No information is available for the first five seconds after the Controller power is turned on. If a ìread pressureî command is issued during this period, the response will be ìNOGAUGE!î

For both logical protocols, the carriage return character (<cr>, 0DH) terminates all commands and responses. Line feeds (0AH) are not required for commands and are not sent with responses. For multidrop protocol only, the attention character (ì$î, 24H) and the selected address character must

precede all commands. These two characters are not sent with the response, since all responses are presumed to go to the host.

Responses from the Controller (except to the PZ command) consist of up to ten ASCII characters, including the carriage return. The PZ response may be up to 45 characters long. Error responses will end with ì!î. However, note that some conditions may be considered an error by the userís system but not by the Controller, or vice versa.

The Communication Module does not maintain independent information about the state of the Controller. When a command changes the state of the Controller in any way, the following commands and their responses will refer to the old state until after the next delivery of information from the Controller. This information is updated every 50 or 100 milliseconds, although occasionally this can be delayed as much as 500 ms.

Tables of Commands and their Responses

This section contains categorized tables listing all commands, along with their particular responses. Responses which are common to multiple command groups are listed and defined in the first table. These are mostly responses which indicate that a command was executed successfully, is invalid, or is inconsistent with the current Controller state or configuration.

Commands and their specific responses are grouped by functional categories in the following tables. Most tables also contain notes giving further information. This manual is not intended to give full descriptions of Controller features, but only of how to access them through the Communications Module. Refer to the ***Controller Userís Manual*** for information on use of these features.

The sensor modules reside in Controller Slots or CC (937A), A, and B. The five sensor channels, HC/CC, A1, A2, B1, B2, are usually identified in commands and responses as channel numbers 1-5. Most modules can be single or dual channel. Cold Cathode Modules contain only one channel, so they are in channel numbers 1, 2, and 4. All references to Slot CC apply to the 937A only. Cold Cathode are abbreviated CC in the tables.

RESPONSES COMMON TO MULTIPLE COMMANDS Command-specific are listed with their command groups	
RESPONSE	**MEANING**
CALLOCK!	User calibration functions are locked out
COMLOCK!	Control and configuration commands are locked out, but commands that only read information may be used.
MISCONN!	A Pirani, convection Pirani, or thermocouple sensor is not connected correctly, or its filament is broken.
NOGAUGE!	There is no module in the channel, or a module other than the required one is in the standard slot, or a Capacitance Manometer Module has its DIP switches in invalid positions. In response to C1 or C2 commands, the ion or control sensor module is missing or the control sensor is inappropriate as a combination sensor, improperly connected or has a broken filament.
NOT929!	The Controller is not a 929A
NOT937!	The Controller is not a 937A
NOT CC!	The sensor is not a cold cathode sensor
NOT CM!	The sensor is not a capacitance manometer
NotCMD!	The characters received did not form a valid command
NOT EB!	The Hot Cathode Degas Module is not electron bombardment type
NOT HC!	The sensor is not a hot cathode sensor
NOT ION!	The sensor is not an ion (hot or cold cathode) sensor
NOTCONV!	The sensor is not a convection sensor
OK	The command was carried out successfully

Table 3: Responses Common to Multiple Commands

PRESSURE READING COMMANDS

COMMAND	FUNCTION	RESPONSES	RESPONSE MEANING
		Also see Common Responses table	
		Single Channels	
Pn (n= 1-5)	Read pressure on channel n	d.dE±ee .dE±ee (d,e = 0-9)	Pressure in selected units (dE+ee, with 2 leading spaces, in single digit resolution regions only)
		HI>E±ee	Above range of $10^{\pm ee}$
		AA_E+ee	At Atmosphere (Pirani only, > $4*10^{+2}$ Torr or equivalint)
		LO<E±ee	Below range of $10^{\pm ee}$
		LO	CC below range, not stared, or in roll- back
		FIL_OFF!	Hot Cathode filament off
		HV_OFF!	Cold Cathode power off
		WAIT	HC or CC startup delay
		LowEmis!	HC off due to low emission
		CONTROL!	HC or CC in controlled state
		PROTECT!	HC or CC in protected state
		NEGATIV!	Reading below 0 pressure[1]
		NOGAUGE!	No sensor on channel
		MISCONN!	Sensor improperly connected, or broken filament (Pirani, Convection, Thermocouple only)
PZ	Read pressure on all channels	5 of above, separated by spaces, ending with <cr>	Same as above (First 4 responses are padded with spaces to make a total of 9 characters each. Channel n response starts with character number 9n-8)
		Combination Channels	
Cn (n=1,2)	Read pressure on Channel n and its combination sensor	(d.)dE+ee (d,e=0-9)	Pressure, as above
		HI	Above combined range
		LO	Below combined range
		NOGAUGE!	Sensor missing/misconducted

☞ **Capacitance manometers only. Signal represents negative pressure as presently calibrated. User calibrated or head adjustment is needed.**

Table 4: Pressure Reading Commands

SET POINT AND HOT CATHODE SENSITIVITY VALUE COMMANDS

COMMAND	FUNCTION	RESPONSES	RESPONSE MEANING
	Also see Common Responses table		
RLYn=d.dE±ee RLYn=0	Set, Disable, or Read relay set point value for Channel n	OK	Action taken
RLYn		OUT!	Value to be set is out of range
(n=1-5 d,e = 0-9)		d.dE±ee (d,e = 0-9)	Present value in selected unit
PROn=d,dE±ee PROn=0 PROn (n =1,2,4 d,e = 0-9)	Set, Disable, or Read protection set point value for Channel n		
CTLn=d,dE±ee CTLn=0 CTLn (n =1,2 d,e = 0-9)	Set, Disable, or Read control set point value for Channel n		
SENn=d.dE±ee SENn (n = 1,2-HC only d,e = 0-9)	Set or Read HC sensitivity value for channel n[1]	d.dE+ee (d,e = 0-9)	Present value in selected units[1]

HC Protection set points may not be disabled.
Sensitivity values are in inverse units (UNIT-1), just as on the front panel. If desired value is 10/Torr, enter 1.0E+01.

Table 5: Set Point and Hot Cathode Sensitivity Value Commands

SET POINT RELAY COMMANDS[1]

COMMAND	FUNCTION	RESPONSES	RESPONSE MEANING
	Also see Common Responses table		
ERn XRn (n= 1-5)	Enable set point relay n Disable set point relay n	OK	Action taken
Relays	Read state of relays 1-5	rlyRRRRR, (R=0 or 1)	0: Inactive (NC closed) 1: Active (NO closed)

Relay enable states are not saved in nonvolatile memory.

Table 6: Set Point Relay Commands

COLD CATHODE POWER CONTROL COMMANDS[1]			
COMMAND	**FUNCTION**	**RESPONSES**	**RESPONSE MEANING**
	Also see Common Responses table		
ECCn (n= 1,2,4)	Enable Channel n Cold Cathode high voltage	OK	Action taken
		AGAIN	Disabled, repeat enable command to override[3]
		PENDING	Action will be taken if not blocked by some condition. (Confirm after 500 ms)
		PROTECT!	Channel is in protected state[4]
		CONTROL!	Channel is in controlled state[5]
		PS_FAULT!	Power supply failure, or direct power supply disable from REMOTE connector (jumper=PS)[5]
		REARdis!	Disabled from REMOTE connector (jumper=SW), or from Analog Module connector (Slot CC only)[5]
XCCn (n= 1,2,4)	Disable Channel n Cold Cathode high voltage[7]	OK	Action taken

☞ **See notes after Hot Cathode Command table**

Table 7: Cold Cathode Power Control Commands

HOT CATHODE POWER CONTROL COMMANDS[1]			
COMMAND	**FUNCTION**	**RESPONSES**	**RESPONSE MEANING**
		Also see Common Responses table	
EFILn (n= 1,2)	Enable Channel n Hot Cathode filament[2]	OK	Action taken
		AGAIN	Disabled, repeat enable command to overide[3]
		PENDING (EFILn only)	Action will be taken if not blocked by some condition. (Confirm after 500 ms)
		PROTECT!	Channel is in protected state[4]
		CONTROL!	Channel is in controlled state[5]
		LowEmis!	Filament is off because emission current was too low[4]
		LOCAL!	The LOCAL/REMOTE switch on the Controller is in the LOCAL position[6]
		REAR!	The LOCAL/REMOTE switch on the Controller is in the REMOTE position, but filament and degas are controlled by the HC rear panel REMOTE connector[6]
EDEGn (n=1,2)	Enable Channel n Hot Cathode degas	FIL_OFF! (EDEGn only)	Filament is off[8]
		COM dis! (EDEGn only)	Filament is off, disabled by XFILn command[8]
XFILn (n=1,2)	Disable Channel n Hot Cathode filament[7]	OK	Action taken[7]
XDEGn	Disable Channel n Hot Cathode degas[7]	LOCAL!	The LOCAL/REMOTE switch on the Controler is in the LOCAL position[6]
		REAR!	The LOCAL/REMOTE switch on the Controller is in the REMOTE position, but filament and degas are controlled by the HC rear panel REMOTE connector[6]
DEGAS	Read degas state of HC sensors in Slots HC and A	degasDD (D=1,0, or X)	1: Degas on 0: Degas off X: No HC on channel

See notes on following page

Table 8: Cold Cathode Power Control Commands

Hot and Cold Cathode Power Control Commands

1. Hot and cold cathode enable states are not saved in nonvolatile memory. These sensors are initially off when the Controller power is turned on.

2. WARNING: Verify that the pressure at the hot cathode sensor is below 10^{-2} Torr before enabling the filament, or it may be damaged. See the ***929A Controller Userís Manual*** section on **Hot Cathode Sensor Power Control** for more information.

3. Again indicates that the sensor was off due to a cause which can be overridden (initial power-on, the C.C. off button, disabling the control set point while controlled, or some cases of switching between the HC power control sources listed in Note 6). The first enable command provides a needed disable, and responds AGAIN. Repeating the same enable command will enable the selected sensor.

4. These transient disable conditions are latched and require a disable command before an enable command can take effect.

5. These continuing disable conditions cannot be overridden by an enable command. The condition must be eliminated before an enable can take effect.

6. Hot cathode filament and degas can be controlled by one of three input sources. These are:

A. The Controller front panel buttons, selected by the Controllerís LOCAL/REMOTE switch in the LOCAL position,

B. The Hot Cathode Module REMOTE connector, selected by the REMOTE switch position and a connection to the Rear Enable terminal of the REMOTE connector, and

C. The Communications Module, selected by the REMOTE switch position with no connection to the REMOTE connector. The Communications Module cannot change this input source selection. These responses indicate that the HC filament and degas power are controlled by A or B above, and are not affected by communications commands. The actual state of the filament or degas may be either on or off.

7. A disable command remains in effect until the corresponding enable command. Other enabling methods cannot override it.

8. Filament must be on before degas can be turned on.

USER CALIBRATION COMMANDS[1,2]			
COMMAND	**FUNCTION**	**RESPONSES**	**RESPONSE MEANING**
	Also see Common Responses table		
ATMn=F[3] ZEROn=F (n=2=5)	Set Channel n atmosphere/zero calibration to factory setting	OK	Action taken
		NO CAL!	This module type cannot be calibrated
		CALLOCK!	Calibration is locked by the XCA command[4]
ATMn=U[3] ZEROn=U (n=2-5)	User calibration: Set Channel n atmosphere/zero calibration to present reading	CONFIRM	Use ATM or ZERO command after 500 ms to determine if successful[5]
ATM[3] ZERO	Read state of calibration on channels 2-5	ATM:CCCC ZERO:CCCC C = F,u, U, X	Calibration state of channels 2-5 F: Factory calibration u: Successful user calibration in past 20 seconds[5] U: Older user calibration[5] X: Module type cannot be calibrated

1. Incorrect use of these commands may cause measurement errors.

2. These commands do not apply to hot or cold cathode sensors.

3. ATM commands do not apply to capacitance manometers.

4. Calibration by these commands may be locked out by the XCAL command, but is NOT locked out by the UCAL ENABLE/DISABLE switch on the rear of the Controller. Calibration lock does not apply to capacitance manometers.

5. For each senor type, only a specific pressure range can be accepted for user calibration. A user calibration attempt outside the allowable range will fail. However, when attempted from the Communications Module, success or failure cannot be determined with certainty until up to 0.5 seconds afterwards, too long to delay the response. Responses to the ATM or ZERO commands indicate if a user calibration attempt has succeeded on each channel within the last 0.5 to 20 seconds. After a series of user calibrations, all ìuî responses will be maintained for 20 seconds after the last successful calibration. After that time, all ìuîresponses will change to ëUî.

Table 9: User Calibration Commands

DIP SWITCH AND JUMPER COMMANDS[1,2]

COMMAND	FUNCTION	RESPONSES	RESPONSE MEANING
	Also see Common Responses table		
HWRESET	Reset DIP switches and jumpers to hardware settings[1]	OK	Action taken
Hot Cathode Module (Channel n = 1,2)			
ECURn=.1[5]	Set Channel n	NOT EB!	Cannot set 4 or 0.4 mA excpt with EB Degas
ECURn=.1[5] ECURn=.4[4,5]	DIP switches[3]		Module[4]
ECURn=.4[4,5]		CHG SWs!	Must change switches on the EB Degas Module to set selected value[5]
ECURn	Read Channel n emission current DIP switches[3]	n)MecmA (M = E or R e = space or ì.î c = 1 or 4 Example: 1)R.1mA)	E: EB Degas Module R: Resistance Degas Module ec: Emission curent DIP switch setting in mA[3] (ec = 0.1, 0.4, 1, or 4)
AUTRAn=ON AUTRAn=OFF	Set Channel n autorange DIP switch to ON or OFF	OK	Action taken
AUTRAn=	Read Channel n autorange DIP switch setting	ARn ON ARn OFF	Autorange Dip switch logical setting
Convection/Pirani Module (Channel n = 2-5)			
CONVn	Read channel n sensor filament type jumper	n)Pt n)Tg	Filament type jumper setting Pt: Platinum (MKS, 10-4) Tg: Tungsten (10-3)

1. None of the settings changed by the commands in this section are stored in nonvolatile memory. If Controller power is turned off and back on, or if the HWRESET command is executed, all settings will revert to the hardware DIP switch and jumper settings.

2. These commands set and read logical equivalent DIP switch settings. Read commands report the current logical DIP switch setting, not the actual hardware switch.

3. ECUR commands apply to DIP switch settings only, not present emission current value, Actual current may be different if autorange or EB degas is on, and will be 0 if filament is off.

4. 0.4 or 4 mA settings are for use with EB Degas Module only.

5. It is only possible to switch between 0.1 and 1 or between 0.4 and 4 mA. To switch between these two groups, it is necessary to change DIP switch 6 on the HC Module and the 1(.1)/ 4(.4) switch on the EB Degas Module.

Table 10: Dip Switch and Jumper Commands

DIP Switch and Jumper Commands continued on next page

DIP SWITCH AND JUMPER COMMANDS[1,2]

COMMAND	FUNCTION	RESPONSES	RESPONSE MEANING
	Also see Common Responses table		
	Capacitance Manometer Module (Channel n = 2-5)		
AUTZn=ON AUTZn=OFF	Set Channel n autozero enable DIP switch to ON or OFF[3]	OK	Action taken
		NOT CM!	Channel is not a capacitance manometer
AUTZn	Read Channel n autozero enable DIPswitch setting[3]	AZn ON AZn OFF	Autozero DIP switch logical setting[3]
HEADn	Read Channel n capacitance manometer range DIP switches[4]	n)RRRRR (RRRRR=1, 10,100,1000, or 10000)	DIP switch setting for fullscale range in Torr[4]
		NOT CM!	Channel is not a capacitance manometer
	Analog Module DIP Switches		
CONTROL	Read control/combination channel DIP switch setting	c1s, c2s	Control/combination sensor for ion sensor in Channel
		(c1s and c2s= B1 or B2 followed by space or X, or XXX)	HC/CC (firs group) and Channel A1 (second group) Examples: 1. B2, B1X 2. B1x, XXX 3. XXX, B2 B2: B2 selected and valid B1X: B1 selected, but not a valid control sensor XXX: Ionsensor slot does not have a valid ion sensor module.
DELAY	Read cold cathode delay DIP switch setting	3 Sec. 30 Sec.	Delay after CC turn-on until its outputs ar valid
FREQ	Read line frequency DIP switch setting	50 Hz 60 Hz	Line frequency DIP switch setting
UNIT	Read pressure unit DIP switch setting	Torr, mbar, Pascal, micron	Unit of measure used for all

1. None of the settings changed by the commands in this section are stored in nonvolatile memory. If Controller power is turned off and back on, or if the HWRESET command is executed, all settings will revert to the hardware DIP switch and jumper settings.

2. These commands set and read logical equivalent DIP switch settings. Read commands reflect the current logical DIP switch setting, not the actual hardware switch.

3. AUTZ commands apply to DIP switch settings only, not present autozero state. DIP switch enables autozero operation; other conditions are also required for auto zeroing to occur.

4. Refers to DIP switch setting only. Does not indicate actual head type, which cannot be detected. For proper operation, switch setting and head range must match.

SECURITY LOCK COMMANDS See the section Special Security Lock Commands for more information			
COMMAND	**FUNCTION**	**RESPONSES**	**RESPONSE MEANING**
	Also see Common Responses table		
EFRONT XFRONT	Enable front panel[1] Disable front panel[1]	OK	Action taken
FRONT	Read state of front panel lock	FP FREE FP LOCK	Front panel is enabled Front panel is disabled
ECAL XCAL	Enable user calibration[2,4,5] Disable user calbration[2,4,5]	OK	Action taken
CAL	Read state of user calibration lock[2,4,5]	CALFREE CALLOCK	User calibration is enabled[2,5] User calibration is disabled [2,5]
ECOM XCAL	Enable/Disable communication interface commands that change Controller operation[3,4]	OK	Action taken
COM	Read state of command lock[3,4]	COMFREE COMLOCK	Commands are enabled[3] Commands are disabled[3]

1. This lock can also be locked and unlocked from the Controllerís front panel. See Controller Userís Manual, Operating the Controller, Using the Front Panel Controls, Pressure Mode, Front Panel Control Lock section.

2. These commands do not apply to the UCAL ENABLE/ DISABLE switch on the Analog Module, nor does that switch affect calibration via communications commands.

3. Commands that only read pressure or other Controller conditions are not affected. Commands that are locked are any command that contain an ë=í, and any that enable or disable a function.

4. These locks can also be cleared by turning on Controller power with the MODE SELECT switch set to LEAK TEST.

5. Calibration lock does not apply to capacitance manometers.

Table 11: Security Lock Commands

OTHER COMMANDS

COMMAND	FUNCTION	RESPONSES	RESPONSE MEANING
	Also see Common Responses table		
Tt (t = 0,1,4,8)	Set delay in ms from end of command to start of response, for R-S485 line reversal[1,2]	OK NOT485!	Action taken Communication is not in multidrop mode
TD	Read time delay	t ms	Time delay is t milliseconds
GAUGES	Read sensor module types presently installed	gaT1T2T3 Tn=2 character module type in Slot HC?CC, A, and B	Hc: Hot cathode Cc: Cold cathode Pr: Dual Pirani Cv: Dual Convection Pirani Tc: Dual Thermocouple Cm: Dual Capacitance Manometer P1: Single Pirani C1: Single Convection Pirani T1: Single Thermocouple M1: Single Capacitance Manometer Nc: No module in slot Wc: Wrong module in HC/CC
VER	Read Controller and Communications Module software version number	c.cc,m.mm (c, m = 0-9)	c.cc: Controller version m.mm: Communications Module version

1. On Controller power-up, delay is set to 8 ms

2. Communications Module releases line in 1-2 bit times after end of response.

Special Security Lock Commands

There are three groups of commands that are used for locking the operation of certain functions of the 929A and 937A Controllers. Each group contains commands to lock, unlock, and display the lock state of a function. The three functions are the front panel controls, operation changes through Communication Module commands, and calibration of thermal conductivity sensors. In each case, the state of the lock can also be changed from the front panel. These commands are given in the table **Security Lock Commands**. This section gives a more complete description of them.

Front Panel Lock

The XFRONT command disables the front panel switches and locks the Controller in the PRESSURE mode. The EFRONT command enables all front panel switches, except possibly the hot cathode filament and degas buttons, which may also be disabled by the REMOTE/LOCAL switch. The FRONT command reports the state of the front panel lock. The REMOTE indicator on the display will be on when either the entire front panel or just the filament and degas buttons are disabled.

The front panel lock may also be changed from the front panel by the following steps:

1. Rotate the GAUGE SELECT switch to channel B2 (the bottom channel) and the FUNCTION SELECT switch to PRESSURE.
2. Hold the UP button in and press the DOWN button slowly 4 times.
3. In the 937A, the display now reads ìnot LOCî if the front panel is enabled or ìLOCî if the front panel is disabled. In the 929A, the above procedure invokes the setup review function. Press the UP button until the display shows one of these two messages. Release the buttons.
4. To change the state of the front panel lock, hold down the DOWN button and push the UP button once. Continuing to push the UP button will not continue to toggle between enabled and disabled states. Release the buttons.
5. Push the UP button once to return to normal display after a few seconds.

Communications Lock

The XCOM command locks out communications commands which change Controller operation. For example, commands for enabling and disabling sensors or setting set points are disabled. However, commands which get information, such as reading pressure or relay status, function normally. The ECOM command unlocks communications so all commands function

normally. The COM command can be used to determine if communications is locked out. Communications may also be unlocked by turning on Controller power while in the LEAK TEST function.

Calibration Lock

The XCAL command locks out calibration of Pirani, convection, and thermocouple (but not capacitance manometer) sensors, both over communications and from the front panel. The ECAL command unlocks the calibration commands. (The switch on the rear panel of the Analog Module can still disable calibration from the front panel only.) The CAL command can be used to determine if calibration is locked out by communications. Calibration lock may also be cleared by turning on Controller power while in the LEAK TEST function.

Product Warranty

Extent of the Warranty

MKS Instruments, Inc., HPS™ Products warrants the HPS™ Series RS-232 / RS-485 Optional Communications Module and its accessories to be free from defects in materials and workmanship for one (1) year from the date of shipment by HPS™ or authorized representative to the original purchaser (PURCHASER). Any product or parts of the product repaired or replaced by HPS™ under this warranty are warranted only for the remaining unexpired part of its one (1) year original warranty period. After expiration of the applicable warranty period, the PURCHASER shall be charged HPS™í current prices for parts and labor, plus any transportation for any repairs or replacement.

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The obligations of HPS™ under this warranty shall be at its option: (1) to repair, replace, or adjust the product so that it meets applicable product specifications published by HPS™ or (2) to refund the purchase price.

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II. Damages or malfunctions due to chemical or electrolytic influences or use of the product in working environments outside the specification.

III. Fuses and all expendable items which by their nature or limited lifetime may not function for a year. If such items fail to give reasonable service for a reasonable period of time within the warranty period of the product; they will, at the option of HPS™, be repaired or replaced.

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Warranty Performance

To obtain warranty satisfaction, contact the following: MKS Instruments, Inc., HPS™ Products, Inc., 5330 Sterling Drive, Boulder, CO 80301, USA, at phone number (303) 449-9861. You may be required to present proof of original purchases

Notes